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AUTHOR Vargha-Khadem, Faraneh; Isaacs, Elizabeth
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ABSTRACT

The study sought to determine whether children with unilateral cerebral lesions sustained either prenatally or postnatally suffer from deficts in learning and memory skills and whether these differentiate left-sided from right-sided lesions. The subjects, 69 children ranging in age from 6 to 17 were divided into four patient groups: hemoplegic Ss classified on the basis of hemispheric side and age at injury (i.e., prenatal vs. postnatal groups). As controls, 16 normal children were matched for age and IQ to 16 Ss in the prenatal left hemisphere group. Ss completed neurological and neuropsychological evaluations, measures of somatosensory and motor function, and assessment of visuo-perceptual memory skills. Among conclusions were that Ss with left cerebral lesions demonstrated verbal memory deficits compared with controls and Ss with right cerebral injuries; the magnitude of verbal memory deficits was greater in left cerebral lesions acquired after birth and as early as 2 months of age; and that, in general, results did not support the notion of plasticity and language sparing, suggesting that even with very early lesions of the left cerebral hemisphere there are persistent verbal memory and learning deficits. (CL)

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THE EFFECTS OF EARLY VS LATE CEREBRAL LESIONS ON VERBAL LEARNING AND MEMORY IN CHILDREN

FARANEH VARGHA-KHADEM

Institute of Child Health, The Wolfson Centre, University of London, and Department of Neurology, Hospital for Sick Children, and

Department of Neurology and Neurosurgery, Mc Gill University and the Montreal Children's Hospital

ELIZABETH ISAACS

Institute of Child Health, The Wolfson Centre, University of London, and Department of Neurology, Hospital for Sick Children.

Address: Institute of Child Health, The Wolfson Centre, Mecklenburgh Square, London, WC1, England

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INTRODUCTION

ALTHOUGH THERE IS AN EXTENSIVE LITERATURE ON THE TYPES AND MANIFESTATIONS OF MEMORY AND LEARNING DEFICITS IN ADULTS WITH LOCALIZED AND GENERALIZED CEREBRAL INJURIES, THERE IS A DEARTH OF INFORMATION ON SUCH PROBLEMS IN CHILDREN WITH CEREBRAL LESIONS. THIS IS PARTLY DUE TO THE FACT THAT THERE ARE VERY FEW, IF ANY, STANDARDIZED MEMORY AND LEARNING TESTS AVAILABLE FOR USE WITH CHILDREN. WHEN ADAPTED VERSIONS OF ADULT MEMORY TESTS HAVE BEEN USED WITH YOUNG POPULATIONS, METHODOLOGICAL PROBLEMS INHERENT IN TESTING YOUNG PATIENTS HAVE OBSCURED A CONSISTENT PATTERN.

IN GENERAL, CHILDREN WITH ACQUIRED UNILATERAL CEREBRAL LESIONS DEMONSTRATE A PATTERN OF COGNITIVE FUNCTIONING WHICH IS FAIRLY CONSISTENT WITH THE HEMISPHERIC SIDE OF DAMAGE. THIS PATTERN, HOWEVER, IS NOT FULLY ANALOGOUS TO THAT OBSERVED IN ADULTS AND IS INFLUENCED BY THE VARIABLES OF AGE AT INJURY, EXTENT OF INJURY, TIME OF TESTING SINCE THE INITIAL INSULT AND THE NATURE OF THE FUNCTIONS BEING ASSESSED. IN VIEW OF NEURONAL REORGANIZATION AND "PLASTICITY" AND THE DIFFERENTIAL EFFECTS OF THE ABOVE VARIABLES, THE PATTERN OF COGNITIVE FUNCTIONING AFTER CEREBRAL INSULT IN YOUNG CHILDREN IS FAR LESS SPECIFIC COMPARED TO THAT OF ADULTS AND SHOWS GREATER RESILIENCE TO PROFOUND SELECTIVE DEFICITS.

THE PURPOSE OF THIS STUDY IS TO DETERMINE WHETHER CHILDREN WITH UNILATERAL CEREBRAL LESIONS SUSTAINED EITHER PRENATALLY OR POSTNATALLY (FROM 2 MONTHS UP TO 15 YEARS) SUFFER FROM DEFICITS IN LEARNING AND MEMORY SKILLS AND WHETHER THESE DIFFERENTIATE LEFT-SIDED FROM RIGHT-SIDED LESIONS.

METHODS

SUBJECTS

A TOTAL OF 69 SUBJECTS, DIVIDED INTO FOUR PATIENT GROUPS, AND A NORMAL CONTROL GROUP COMPRISED THE STUDY POPULATION. PATIENT GROUPS CONSISTED OF HEMIPLEGIC CHILDREN WHO WERE CLASSIFIED ON THE BASIS OF HEMISPHERIC SIDE AND AGE AT INJURY (I.E. PRENATAL VS. POSTNATALLY ACQUIRED CEREBRAL LESIONS). PATIENTS IN THE POSTNATAL GROUPS HAD SUSTAINED THEIR INJURIES FROM TWO MONTHS OF AGE ONWARDS. THE LATEST AGE AT ACQUISITION OF INJURY WAS 14 YEARS IN THE CASE OF THE LEFT HEMISPHERE GROUP AND 15 YEARS IN THE CASE OF THE RIGHT HEMISPHERE GROUP. ALL PATIENTS WERE INVESTIGATED AT LEAST TWO YEARS FOLLOWING THEIR INJURIES.

THE ACQUIRED LESIONS WERE CAUSED BY CASES OF HEMIPLEGIC MIGRAINE, CEREBROVASCULAR ACCIDENTS, LOW GRADE ASTROCYTOMAS, ARTERIO-VENOUS MALFORMATIONS, ABSCESSES AND ACCIDENTS RESULTING IN LOCALIZED CEREBRAL DAMAGE.

AS CONTROLS, 16 NORMAL CHILDREN WERE SELECTED AND AGE AND IQ (FULL SCALE) MATCHED TO 16 PATIENTS COMPRISING THE "PRENATAL LEFT HEMISPHERE" GROUP. SUBJECTS RANGED IN AGE FROM SIX TO SEVENTEEN YEARS.

GROUPS	N	$\bar{X}$ AGE	S.D.
1. PRENATAL LEFT HEMISPHERE	18	10.6	2.8
2. POSTNATAL LEFT HEMISPHERE (2 MOS. - 14 YEARS)	10	10.8	4.0
3. PRENATAL RIGHT HEMISPHERE	15	11.0	4.0
4. POSTNATAL RIGHT HEMISPHERE (4 MOS. - 15 YEARS)	10	10.4	3.9
5. NORMAL CONTROL	16	10.7	2.5

NO SIGNIFICANT DIFFERENCES BETWEEN AGE GROUPS.

TEST MATERIALS

ALL PATIENTS RECEIVED COMPLETE NEUROLOGICAL AND EXTENSIVE NEUROPSYCHOLOGICAL EVALUATION. IN ADDITION, AS PART OF THE DIAGNOSTIC PROCEDURES, ALL PATIENTS HAD CRANIAL COMPUTED TOMOGRAPHY (CT) SCANS. CT SCANS WERE RATED FOR SEVERITY OF STRUCTURAL ABNORMALITY ON A FIVE POINT SCALE RANGING FROM 1- (GROSS LOSS OF SUBSTANCE > 3 CUTS ± VENTRICULAR DILATATION)TO 5- (NORMAL).

ADDITIONAL MEASURES OF THE SEVERITY AND EXTENT OF CEREBRAL DAMAGE WAS PROVIDED BY THE EVALUATION OF SOMATOSENSORY AND MOTOR FUNCTION. SOMATOSENSORY FUNCTION WAS ASSESSED BY TESTS OF 2-POINT DISCRIMINATION ON THE HANDS, TACTILE STEREOGNOSIS, PASSIVE MOVEMENTS OF THE FINGERS AND DOUBLE SIMULTANEOUS STIMULATION ON THE HANDS AND THE BODY. RESULTS OF THESE TESTS WERE RATED ON A FOUR POINT SCALE RANGING FROM 1- (PROFOUND DEFICIT) TO 4- (NORMAL).

THE TWO MEASURES USED TO ASSESS MOTOR FUNCTION WERE TESTS OF HAND GRIP STRENGTH AND RAPID FINGER TAPPING. RESULTS OF THESE TWO TESTS WERE RATED ON AN EIGHT POINT SCALE RANGING FROM 1- (PROFOUND DEFICIT) TO 8- (NORMAL).

FROM THE NEUROPSYCHOLOGICAL TESTS, SEVERAL MEASURES RELATING TO MEMORY AND LEARNING WERE SELECTED FOR ANALYSIS. THESE MEASURES CONSISTED OF FULL SCALE IQ (WECHSLER-BELLEVUE OR WISC), DIGIT SPAN AND CODING (SUBTESTS OF THE WECHSLER-BELLEVUE OR WISC), PAIRED ASSOCIATE LEARNING (WECHSLER MEMORY SCALE), IMMEDIATE AND 90 MINUTES DELAYED RECALL OF LOGICAL MEMORY SUBTEST (WECHSLER MEMORY SCALE), MEMORY QUOTIENT (WECHSLER MEMORY SCALE), COMPOSITE SCORE OF 90 MINUTES DELAYED RECALL ON PAIRED ASSOCIATE LEARNING AND LOGICAL MEMORY SUBTESTS AND IMMEDIATE MEMORY FOR RELATED WORDS (DETROIT TEST OF LEARNING APTITUDE).

VISUO-PERCEPTUAL MEMORY SKILLS WERE ASSESSED USING MEASURES OF COPY AND 45 MINUTES DELAYED RECALL OF THE REY-OSTERRIETH COMPLEX FIGURE AND IMMEDIATE AND DELAYED RECALL (45 MINUTES) OF VISUAL REPRODUCTION SUBTEST (WECHSLER MEMORY SCALE).

PERFORMANCE ON THESE TEST MEASURES WAS COMPARED ACROSS THE FIVE GROUPS.

RESULTS

CT SCANS, SOMATOSENSORY AND MOTOR RATINGS

IN ORDER TO ENSURE THAT THE PATIENT GROUPS WERE NOT SIGNIFICANTLY DIFFERENT WITH RESPECT TO INDICATORS OF SEVERITY AND EXTENT OF CEREBRAL LESIONS, UNIVARIATE ANALYSES OF VARIANCE (1 x 4) WERE CARRIED OUT ON THE RATED SCORES DERIVED FROM CT SCANS AND SOMATOSENSORY AND MOTOR TESTS. THESE ANALYSES INDICATED NO SIGNIFICANT DIFFERENCES BETWEEN PATIENT GROUPS.

GROUPS	CT SCANS $\bar{X}$ RATED SCORES 1----------->5 ABNR.	NORM.	SOMATOSENSORY $\bar{X}$ RATED SCORES 1----------->4 ABNR.	NORM.	MOTOR $\bar{X}$ RATED SCORES 1----------->8 ABNR.	NORM.
PRENATAL LEFT	2.9		2.5		3.3	
POSTNATAL LEFT	2.5		3.1		3.6	
PRENATAL RIGHT	2.3		2.4		3.4	
POSTNATAL RIGHT	1.7		3.1		5.3	
	$F = 1.48$; P NS		$F = 1.01$; P NS		$F = 1.44$; P NS	

INTELLIGENCE TESTS

SEPARATE UNIVARIATE ANALYSES OF VARIANCE (1 x 5) WERE CARRIED OUT TO DETERMINE THE EFFECTS OF HEMISPHERIC SIDE AND AGE AT INJURY ON INTELLIGENCE TEST PERFORMANCE.

GROUPS	WECHSLER-WISC MEAN SCALED SCORES FS IQ	V IQ	P IQ	DIGIT SPAN	CODING
PRENATAL LEFT HEMISPHERE	95.5	95.7	96.2	7.8	8.0
POSTNATAL LEFT HEMISPHERE	88.7	85.2	94.4	6.2	8.2
PRENATAL RIGHT HEMISPHERE	99.4	101.6	96.7	7.9	8.8
POSTNATAL RIGHT HEMISPHERE	95.9	96.3	92.2	9.0	8.2
NORMAL CONTROL	100.0	96.8	103.3	9.5	9.3
	$F = 1.63$	$F = 2.3; p = .06$	$F = 1.23$	$F = 1.54$	$F = 0.62$

PAIRED ASSOCIATE LEARNING

WEIGHTED SCORES ON THE PAIRED ASSOCIATE LEARNING SUBTEST OF THE WECHSLER MEMORY SCALE WERE SUBJECTED TO A UNIVARIATE ANALYSIS OF VARIANCE. MAXIMUM SCORE ON THIS SUBTEST WAS 21. RESULTS OF THE ANOVA INDICATED A SIGNIFICANT MAIN EFFECT OF GROUPS ($F = 3.71$; df 4,63; $P < 0.009$).

GROUPS	PAIRED ASSOCIATE LEARNING (MEAN SCORES - MAX = 21)
PRENATAL LEFT HEMISPHERE	+ 13.25
POSTNATAL LEFT HEMISPHERE	* 15.05
PRENATAL RIGHT HEMISPHERE	16.1
POSTNATAL RIGHT HEMISPHERE	* 13.3
NORMAL CONTROL	17.2

+ SIGNIFICANTLY IMPAIRED RELATIVE TO NORMAL CONTROL AND TO PRENATAL RIGHT HEMISPHERE

* SIGNIFICANTLY IMPAIRED RELATIVE TO NORMAL CONTROL

VERBAL MEMORY MEASURES

SCORES DERIVED FROM THE CALCULATION OF MEMORY QUOTIENT(WITH ADJUSTED SCALES FOR CHILDREN), IMMEDIATE AND DELAYED RECALL OF LOGICAL MEMORY, THE COMPOSITE SCORE (BASED ON DELAYED RECALL OF LOGICAL MEMORY AND PAIRED-ASSOCIATE LEARNING) AND MEMORY FOR RELATED WORDS WERE SUBJECTED TO FIVE SEPARATE UNIVARIATE ANALYSES OF VARIANCE. RESULTS OF EACH ANALYSIS INDICATED SIGNIFICANT DIFFERENCES BETWEEN GROUPS.

GROUPS	IMMEDIATE VERBAL RECALL	DELAYED VERBAL RECALL
PRENATAL LEFT HEMISPHERE	* 7.4	* 5.7
POSTNATAL LEFT HEMISPHERE	+ 6.2	* 4.1
PRENATAL RIGHT HEMISPHERE	9.9	8.1
POSTNATAL RIGHT HEMISPHERE	7.9	6.2
NORMAL CONTROL	8.5	7.3

* Significantly impaired vs Prenatal right.

\+ Significantly impaired vs Normal Control & Prenatal Right.

* Significantly impaired vs Normal Control & Prenatal Right.

GROUPS	MEMORY QUOTIENT (Mean = 100)	COMPOSITE SCORE
PRENATAL LEFT HEMISPHERE	• 83.5	• 13.7
POSTNATAL LEFT HEMISPHERE	+ 72.1	• 11.9
PRENATAL RIGHT HEMISPHERE	94.7	16.8
POSTNATAL RIGHT HEMISPHERE	86.9	13.7
NORMAL CONTROL	96.5	15.8

• Significantly impaired vs Normal Control & Prenatal Right.

+ Significantly impaired vs all other groups.

• Significantly impaired vs Normal Control & Prenatal Right.

GROUPS	IMMEDIATE AUDITORY MEMORY FOR RELATED WORDS (%)
PRENATAL LEFT HEMISPHERE	• 49.2
POSTNATAL LEFT HEMISPHERE	+ 43.4
PRENATAL RIGHT HEMISPHERE	58.6
POSTNATAL RIGHT HEMISPHERE	56.4
NORMAL CONTROL	60.1

• Significantly impaired vs Normal Control and Prenatal Right.

+ Significantly impaired vs Normal Control, Prenatal Right and Postnatal Right.

VISUO-PERCEPTUAL MEMORY MEASURES

SEPARATE ANALYSES OF VARIANCE WERE PERFORMED ON SCORES DERIVED FROM THE COPY AND DELAYED RECALL OF THE REY-OSTERRIETH COMPLEX FIGURE AND FROM THE IMMEDIATE AND DELAYED RECALL OF THE VISUAL REPRODUCTION SUBTEST OF THE WECHSLER MEMORY SCALE. RESULTS OF EACH OF THESE ANALYSES INDICATED THAT THERE WERE NO SIGNIFICANT DIFFERENCES BETWEEN GROUPS ON ANY OF THESE TASKS.

CONCLUSIONS

1. CHILDREN WITH LEFT CEREBRAL LESIONS DEMONSTRATE VERBAL MEMORY DEFICITS. THIS IS CLEARLY SHOWN BY THE CONSISTENT EVIDENCE OF IMPAIRMENT ON ALL MEASURES OF VERBAL MEMORY USED IN THIS EXPERIMENT.

2. THE IMPAIRMENTS SHOWN BY PATIENTS WITH LEFT HEMISPHERE LESIONS IS NOT ONLY RELATIVE TO NORMAL CONTROL SUBJECTS, BUT ALSO TO PATIENTS WITH RIGHT CEREBRAL INJURIES, PARTICULARLY THOSE WHICH ARE OF A CONGENITAL NATURE.

3. THE MAGNITUDE OF VERBAL MEMORY DEFICITS, HOWEVER, IS ALWAYS GREATER IN THE CASE OF LEFT CEREBRAL LESIONS ACQUIRED AFTER BIRTH AND AS EARLY AS TWO MONTHS OF AGE.

4. IT SHOULD BE NOTED THAT DEFICITS IN VERBAL MEMORY SKILLS PREVAIL DESPITE THE FACT THAT THE PATIENT GROUPS ARE NOT SIGNIFICANTLY DIFFERENTIATED ON MEASURES DERIVED FROM INTELLIGENCE TESTS. NOR ARE PATIENT GROUPS SIGNIFICANTLY DIFFERENT WITH RESPECT TO INDICATORS OF SEVERITY AND EXTENT OF CEREBRAL LESIONS.

5. AN INTERESTING FINDING IS THAT, WITH THE EXCEPTION OF PATIENTS WITH PRENATAL RIGHT HEMISPHERE INJURIES, ALL OTHER PATIENTS ARE SIGNIFICANTLY IMPAIRED ON VERBAL PAIRED ASSOCIATE LEARNING TASK. THIS SUGGESTS THAT AT LEAST SOME LEARNING CAPACITY MAY BE IRREVOCABLY IMPAIRED WITH ALL LEFT HEMISPHERE LESIONS, REGARDLESS OF AGE AT INJURY, AND THOSE RIGHT HEMISPHERE LESIONS THAT ARE ACQUIRED AFTER BIRTH.

6. IN GENERAL, THESE RESULTS DO NOT SUPPORT THE NOTION OF "PLASTICITY" AND LANGUAGE SPARING AND THEY SUGGEST THAT EVEN WITH VERY EARLY LESIONS OF THE LEFT CEREBRAL HEMISPHERE THERE ARE PERSISTENT VERBAL MEMORY AND LEARNING DEFICITS.